Improving Sheet Metal Quality and Product Throughput with Bently's Machinery Management System

by Marcelo Lupinucci

Engineering Solutions
Development Manager
Bently Nevada Latin America
e-mail: marcelo.lupinucci@bently.com

Jorge Pérez

Quality Assurance Engineer
Siderar

Guillermo Davilla

Engineer
Siderar

and Leandro Tiseyra

Engineer
Siderar

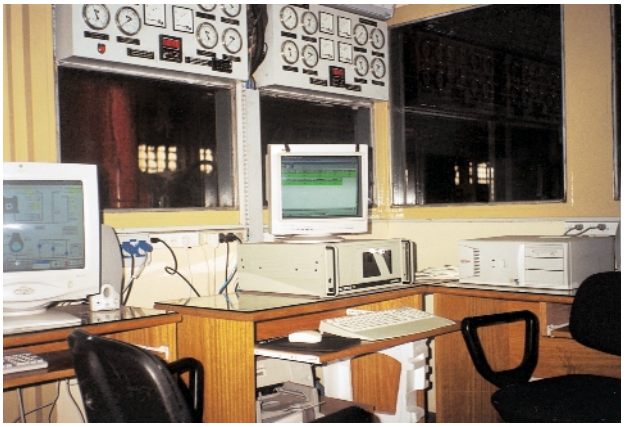
Siderar, Argentina's largest producer of flat-rolled steel.

Siderar is Argentina's largest producer of flat-rolled steel and a member of the TECHINT GROUP, an industrial conglomerate with operations in Argentina, Italy, Venezuela, Mexico, and Brazil. Iron ore and coal are used as raw materials at the Siderar plant to make hot- and cold-rolled steel sheets and coated products, including hot dip galvanized, pre-painted, and tin-plated sheets and coils. The company exports the processed steel products to more than 40 countries, supplying major industries including automotive, construction, railroad, oil, packaging, and electrical appliance manufacturers.

The Siderar plant is located on the West Bank of the Paraná River, 7 km from the city of San Nicolás de los Arroyos and 232 km north of the city of Buenos Aires. It employs over 5500 people and produces approximately 2 million metric tons per annum, with 1999 sales at nearly one billion US dollars. Its proximity to major roads, railroads, and rivers ensures raw material access and facilitates distribution of manufactured products.

The integrated-cycle facilities include a dedicated port (Ingeniero Buitrago Port), a four-battery coke plant, a by-products plant, a sinter plant, two blast furnaces, a Linz Donkaawitz (LD) steel shop with three basic oxygen furnaces, a ladle furnace, a continuous casting machine, a hot-rolling mill, a cold-rolling mill and finishing lines, and a tin plating line. In addition, auxiliary services include a power plant, an oxygen reduction plant, maintenance shops, and an important rail net.

Beginning in 1993, Siderar and Bently Nevada Corporation initiated



Predictive Maintenance Department office, with Trendmaster® 2000 System display on right.

a program of protection of critical machinery and secondary equipment, and data management (Move Data, Not People®), with the installation of a Bently machinery monitoring and protection system. The San Nicolás Plant now has three Bently Nevada Trendmaster® 2000 for Windows NT® systems to address non-critical machinery in different sectors of the facility: the power plant, the blast furnace, and the steel mill. The Predictive Maintenance Department (SEMA) now communicates from a remote location through the Trendmaster® 2000 system to monitor the mechanical condition of this class of rotating equipment installed throughout the facility.

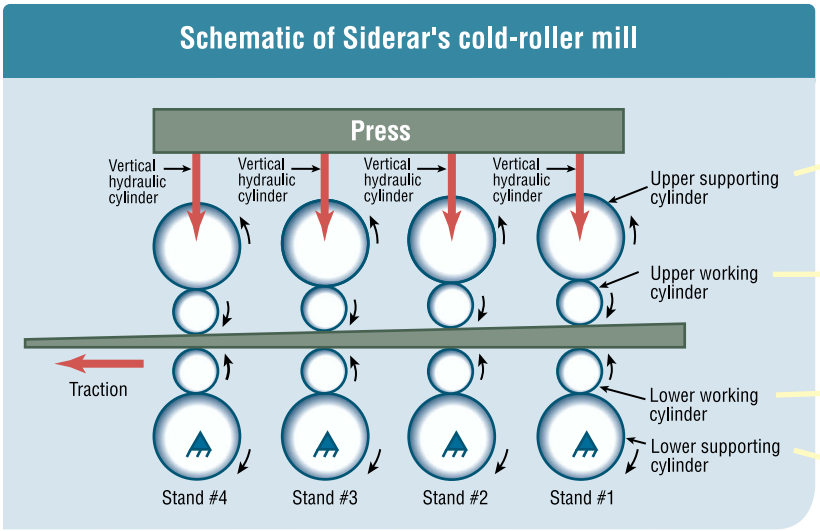


Figure 1a.

Uses of Cold-Rolling Products

Cold-rolled products are present in a wide range of items used in our daily lives. The end products include such items as automobiles, roofs, ceilings, air conditioning ducts, railing guards for highways and railroads, oil pipelines, cans for food, and electrical appliances such as refrigerators and microwave ovens. These are only a few of the many uses for these raw materials, some of which have extremely high quality standards.

> *"The problem is known as chattering, ... 'a series of waves or ridges on the surface of a piece of metal that has been imperfectly drawn or extruded.'"*

How Does a Cold-Roller Work?

Siderar's cold-roller machine, shown in Figure 1, has four stands, each of which uses four cylinders – two working and two supporting cylinders. The working rollers are of a smaller diameter and they come in direct contact with the steel. Traction force is obtained through eight continuous current motors of 373 kW (500 hp) operating at 140 rpm. The working and lower supporting cylinders are fixed whereas the vertical hydraulic cylinders move the upper cylinders, providing the compressive force. The upper working cylinders press the metal sheet that goes between the upper and lower working cylinders and, through compression, create a thinner sheet. The greater the pressure between cylinders, the stronger the compression and the thinner the finished processed sheet. Figure 1 shows a schematic of the cold-roller machine. The cylinders in Stand Number 4 have the greatest impact on the sheet's final surface quality.

> *"Chattering can now be reliably detected and correlated with the direct vibration level in the stands ...."*

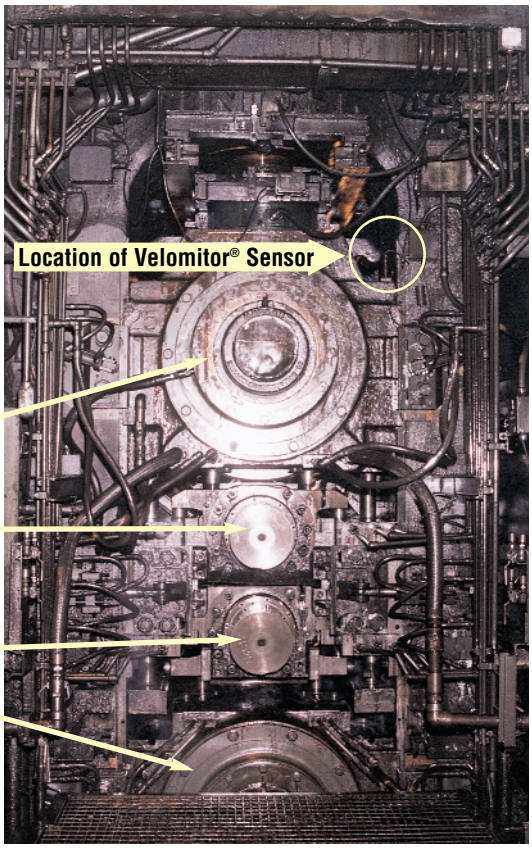


Figure 1b. Stand #2 at Siderar's cold-roller mill.

Chattering

In July 1995, Mr. Jorge Pérez, a Quality Assurance Engineer in charge of the Cold Technology Department, and his group (Engineer

Figure 2. Shape of the sheet with chattering.

Leandro Tiseyra and Engineer Davilla Guillermo) informed Bently personnel about the problem they were experiencing with their production quality. The problem is known as *chattering*, which is a vibratory phenomenon that occurs in two different frequency bands of motion. It is defined as "a series of waves or ridges on the surface of a piece of metal that has been imperfectly drawn or extruded."

Chattering occurs when any of the roller cylinders vibrate, resulting in a rolled sheet that does not exhibit uniform bulk or surface characteristics. Vibration of the cylinders causes a poor quality sheet with the phenomenon becoming even more evident as the sheet gets thinner. The photograph in

"... when chattering occurs, costs become higher ..."

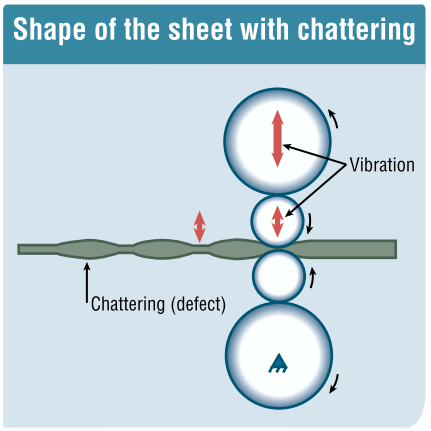


Figure 3.

Figure 2 shows a thin sheet with chattering defects, which can be detected under light reflection. The dark lines show the "valleys" in the plate, and the light lines show evidence of the "peaks."

Due to market demands for quality, sheets produced with these faults are discarded when variations exceed 5% of the average thickness. Consequently, when chattering occurs, costs become higher and delays in fulfillment of delivery terms are incurred. Figure 3 provides a cross-section schematic illustrating the chattering effect on the metal plate.

In general, for a tandem cold-roller mill, there are two types of frequency bands where the chattering phenomena can be observed. In the range of 120 to 250 Hz, the working and support cylinders move in phase with each other, and create a third harmonic frequency. When the working and support cylinders vibrate out of phase, it is known as the fifth harmonic frequency. The vibrations noted at the Siderar plant were found to be in the third harmonic (120 to 250 Hz) as can be seen in Figure 4.

The vibrations in the four stands were monitored in order to evaluate the chattering behavior during the processing of tin sheet, which is more sensitive than steel to this phenomenon. Vibrations in the working cylinders were measured using eight seismic velocity transducers (Bently model 9200) fixed to the rollers with a magnetic base. Relationships between the sheet quality and vibration were measured and analyzed over a period of several hours. Frequency responses measured using ADRE® for Windows software were used to produce a direct relation between vibration amplitude, band frequency, and chattering effects.

Figures 4 and 5 show examples of spectrum and trend plots of the cylinder vibrations observed. Sheet chattering was documented as a function of roller vibration, demonstrating that the

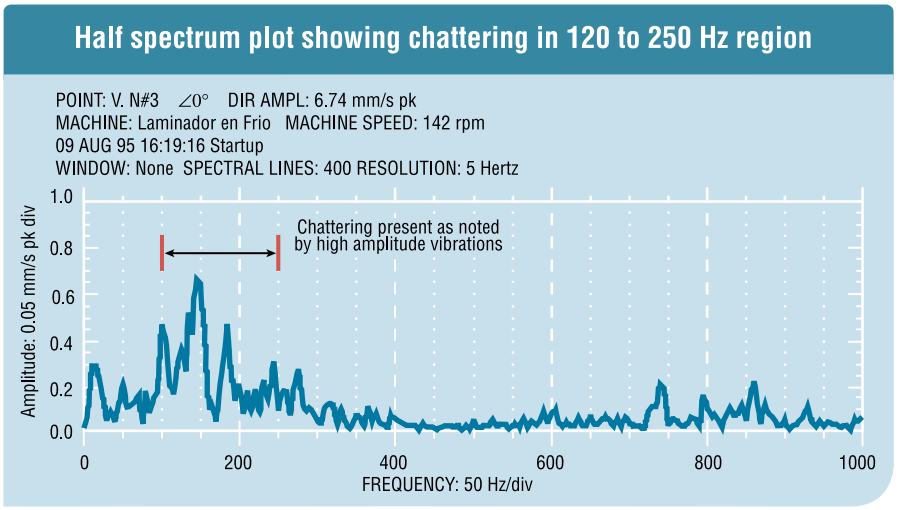


Figure 4.

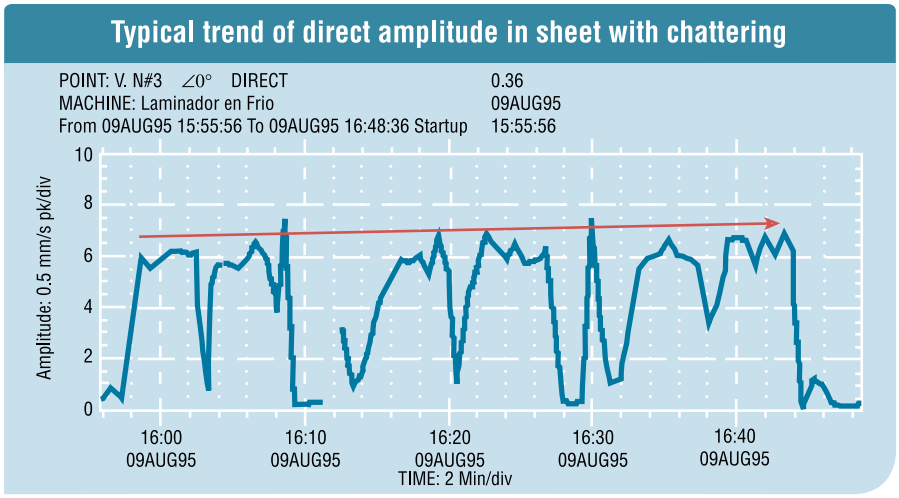


Figure 5.

chattering phenomenon can be detected from the value of direct or overall vibration. It was also found during the testing that the vibration data could be used to detect wear on the cylinders. As a result, chattering can be reliably detected and correlated with the direct vibration level in the stands as it approaches the specific frequency regions that cause the defect.

Figure 5 shows an example trend plot developed during the field testing. This vibration data was collected with the transducers placed on Stand Number 3 as the sheets passed through the rollers. The low amplitudes, or valleys, indicate periods between sheets moving through the stand. The increasing trend of amplitude with time also provides an indication for the operators that the working cylinder is becoming distorted, which also adds to the poor sheet quality.

"The 3300 monitoring system coupled with the Data Manager 2000 has resulted in reduced costs and increased product quality."

Bently Machinery Protection System – The Solution to the Chattering

Based on the results of field testing with a portable ADRE® for Windows system as detailed above, Siderar management decided in May 1996 to install a continuous monitoring system in the rolling mill, with the objective of detecting small levels of chattering. Velomitor® transducers were installed with quick-connect fittings in the upper supporting rollers at both sides of each cylinder. Figure 6 shows the Velomitor® sensor on Stand Number 2.

"Vibrations in the working cylinders were measured using eight seismic velocity transducers fixed to the rollers ..."

These sensors are connected to Bently Nevada 3300/55 Velocity Monitors. The 3300 Series monitoring system uses a serial interface with Modbus® protocol to communicate with the PLC that controls the roller.

Two types of signals for each stand are sent to the operators' screens:

- A trend diagram of the direct vibration component (via the system's Modbus interface)
- An alarm/danger signal from the 3300 System (via the system's relay contacts)

According to previous experience, the values were set at 2 mm/sec for "alarm" and 4 mm/sec for "danger." When the operator receives the alarm signal, he slows down the roller velocities in order to diminish the vibration,

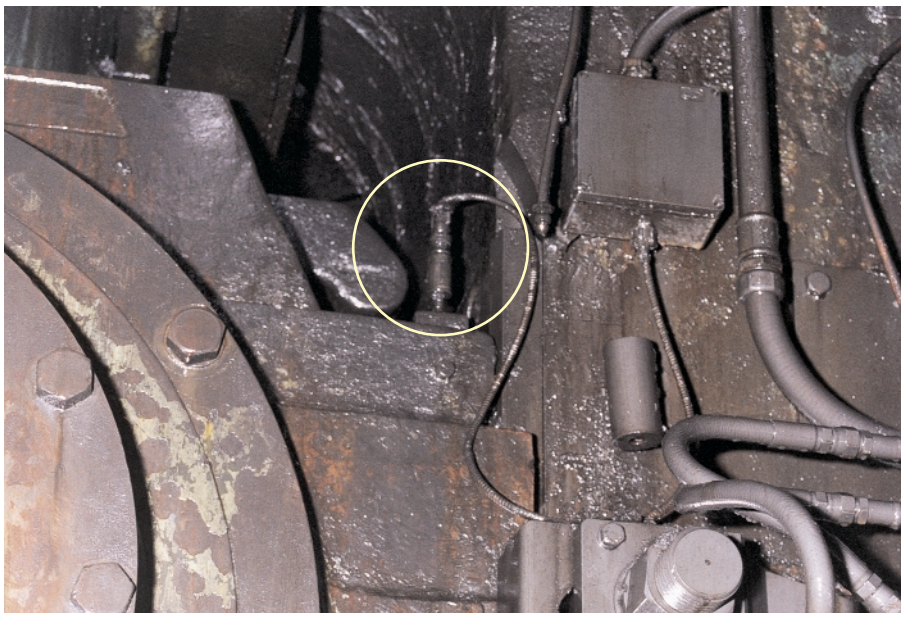


Figure 6. Location of the Velomitor on Stand #2.

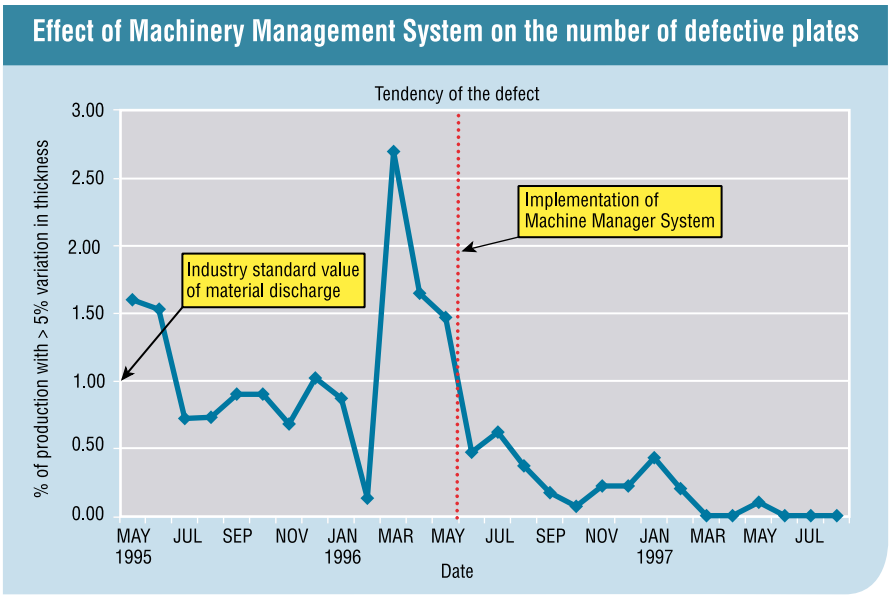


Figure 7.

thereby avoiding chattering. If, at the same time, there is an increasing direct vibration tending toward the danger level, the affected cylinder is replaced. Since this vibration-based control philosophy was adopted, defects have decreased significantly. Figure 7 shows the decreasing trend in discarded material since the new system was installed.

Machinery Protection System and Data Manager® 2000

Due to the success of this monitoring in reducing chattering, improved data management techniques are now in use at the plant with the addition of Data Manager® 2000 software. This system allows collected data to be analyzed over periods of time, or during critical conditions such as startup and shutdown. The 3300 monitoring system coupled with the Data Manager 2000 has resulted in reduced costs and increased product quality through detection and resolution of the chattering defect phenomenon. This experience has been shared with Siderar's other operations that were experiencing similar chattering problems.

Bently Nevada is well known as a top company in protection of rotating equipment, information management, and customer technical support due to its experience covering over 40 years in the market. However, this particular application highlights the Company's wide versatility in addressing "all" your machinery management needs.